Applied Reverberation Modeling Workshop

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LONG TERM GOALS

Improve accuracy, fidelity, and speed of reverberation models for modeling, simulation, training and sonar system performance predictions.

OBJECTIVES

The objective is to achieve more efficient transitions from the 6.1 basic research community to the applied modeling community.

APPROACH

The approach is to: 1) develop enhanced understanding of 6.2/6.3 needs within the 6.1 community (emphasis on physics rather than signal processing); 2) develop long-term interactions between 6.2/6.3 and 6.1 researchers (addressing current/future Navy needs through FNC or alternate paths) and 3) identify topics that require long-term 6.1 basic research.

WORK COMPLETED

The PI worked closely with Tony Eller (ASPM reverberation modeler) to identify physics upgrades that would improve speed and/or fidelity. The PI had close association with the HIFAST program, via two formal review meetings and recommendations to Mike Vaccarro (ONR program manager of HIFAST program) for reverberamation modeling improvements. The PI also interacted with the air community (Carrie Root) about specific recommendations for reverberation modeling speed and fidelity improvements. The PI provided guidance on several occasions to a software support engineer (John Pinezich, Advanced Acosutic Concepts) developing the air community simulation system, CASE. The PI also continued collaborative modeling with the two operational model leads, Tony Eller (ASPM) and Ruth Keenan (CASS).

RESULTS

As part of the collaborative modeling, the PI collaborated with Tony Eller to: 1) establish ASPM vs energy flux commonality and points of departure, and 2) identify needed upgrades for better physics,

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accuracy without significant runtime penalty. Several model runs were performed in order to evaluate ASPM accuracy, including several Reverberation Modeling Workshop cases: RMW1 Problems 11-13 for reverberation and transmission loss and RMWII Problem T for target echo. Both ASPM and the energy flux model are based on the pioneering work by Brekovskikh [1] and Weston [2] who independently developed ideas of incoherent propagation in a waveguide. Later, Zhou [3] and others extended their work to reverberation.

ASPM/ASTRAL agreed reasonably well with the energy flux model reverberation and propagation predictions for all of the problems. Since the energy flux model result (EF) agrees with the normal mode solution to within a fraction of a dB it was considered here as a 'benchmark'. Figure 1 shows the results for one of the test cases, RMW Problem XIII.

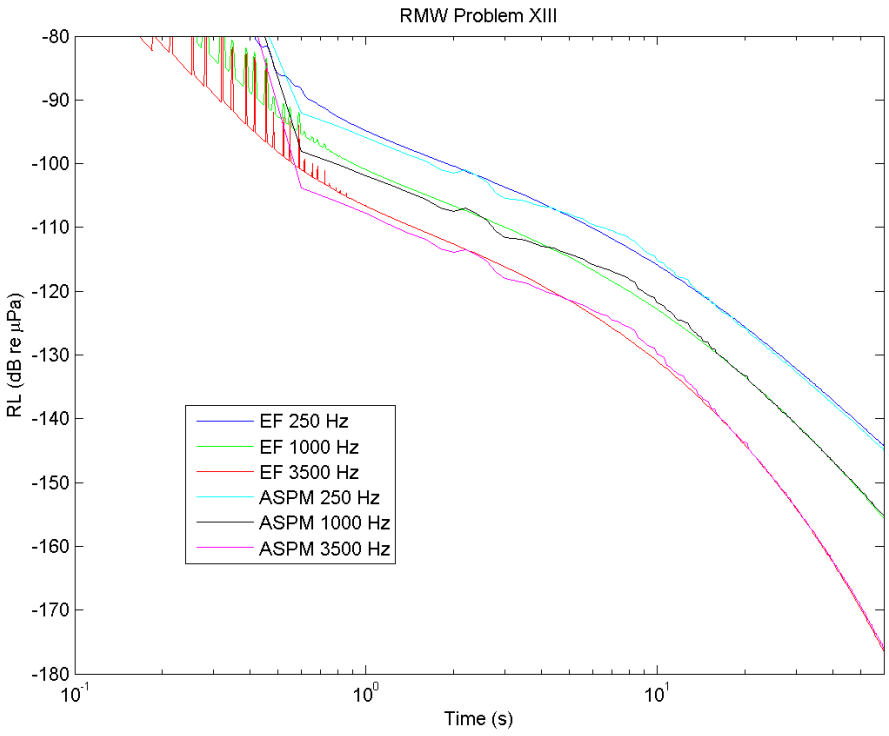

Figure 1. Comparison of ASPM with an energy flux 'benchmark' (EF) for RMW problem XIII, a 100 m waveguide with a sandy bottom, Lambert's Law scattering kernel and a downward refracting sound speed profile; source/receiver depths are 30/50 m. The comparison indicates that ASPM is reasonably accurate. At early times (less than 1 second) ASPM does not attempt to model the fathometer returns.

The target echo problem, problem T used the same environment (except isovelocity water column) with a point target at 10m depth and 10 km range. As adapted by the Validation of Sonar Performance Assessment Tools: Weston Memorial Workshop [4], the source level was specified at 214 dB re 1uPa^2 at 1m. Here, the normal mode result is given as a benchmark. The energy flux result is approximate inasmuch as it uses an approximation of the mode angles. The 'ASPM' result was performed outside the configuration managed code. It is believed that the ASPM solution could be improved by

including phase information, i.e., the shape of the target time spread is driven here by Lloyds mirror interference between target and sea surface.

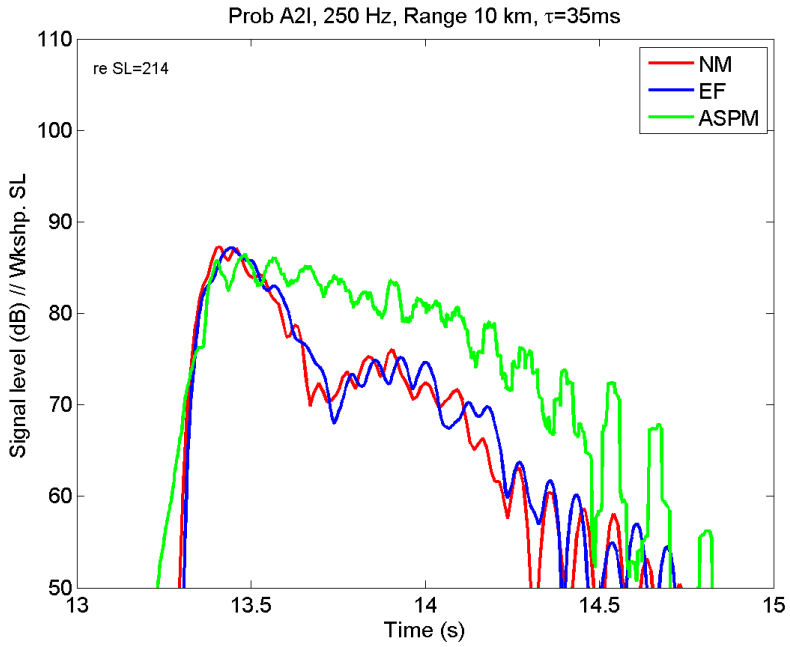

Figure 2. Comparison of mode, energy flux and ASPM models for scattering from a point target of target strength 8 dB at 10 km range. The ASPM arrivals do not capture the null at 13.75 seconds which is due to Lloyds mirror interference. Incorporating phase into the ASPM result would improve its fidelity.

IMPACT/APPLICATIONS

It is anticipated that improved understanding of the 6.2/6.3 modeling issues by the 6.1 community will lead to enhanced transition of modeling research from the 6.1 community. For example, 6.1 research is providing valuable underpinnings for quantitative understanding of fidelity/speed trade-offs that are crucial to simulation and training requirements.

RELATED PROJECTS

The ONR-SPAWAR Reverberation Modeling Workshop is a closely related project that was intended to foster interaction primarily within the 6.1 community and develop benchmark solutions to canonical (principally) shallow-water reverberation problems.

REFERENCES

[1] Weston D.E., Intensity-range relations in Oceanographic Acoustics, J. Sound and Vib., 18, 271-287, 1971.

[2] Brekhovskikh L.M., The average field in an underwater sound channel, Soviet Physics-Acoustics, 11, 126 - 134,1965.

[3] Zhou J.-X, Guan D., Shang E., Luo E. Long-range reverberation and bottom scattering strength in shallow water, Chinese Journal of Acoustics, 54-63, 1982.

[4] Workshop papers are published in Proc. Inst. of Acoustics, 32, Pt 2, 2010.